On the Anatomy of Conus tulipa, Linn., and Conus textile, Linn.

By

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With Plates 1 to 6, and 12 Text-figures.

Since 1895, few workers on the anatomy of mollusca have devoted their attention to the genus Conus. In that year Dr. Bergh (**3**) published an extensive memoir on a large number of species in this genus, and his work may be considered as the most complete, and embracing the greatest number of species examined, though his description of each species was not exhaustive. Troschel (**20**) devoted most of his attention to the radulæ of the different genera and species of which his excellent work is composed, and although he gives a certain number of figures with descriptions of various anatomical points, these latter are for the most part of rather a crude and diagrammatic kind.

While malacologists have done a certain amount towards working out and elucidating the anatomy of various members of this genus, the conchologists, as is generally the case, have produced many excellent monographs, and such names as Reeve, Sowerby, Tryon, Weinkauff and others will always be remembered for the general excellence of their figures and descriptions of the numerous species which are contained in this genus. Various writers have essayed different forms of classification, but for the most part on purely conchological grounds, and when more is known about the inhabitants of these shells, and their different points of resemblance to one

another, whether they vary as much or more than their shells, and if the conchological grouping also holds good from an anatomical point of view, we shall be on the high road to founding a solid and logical form of classification.

The two species with which I shall deal in this paper are Conus tulipa, Linn., and Conus textile, Linn. The specimens of both species were females. The Conidæ belong to the order Prosobranchiata of the class Gastropoda, are diœcious, and according to the most widely accepted form of classification, Conus tulipa is included in that sub-genus, or, as some would have it, section, of the genus Conus, called Rollus by Montfort, while Conus textile forms the type of the sub-genus or section Cylinder, of the same author.

Rollus was first described by Montfort in 1810 (**15**, p. 395), with Conus geographus as the type, and the sub-genus was characterised as follows: "Shell light, sub-cylindrical, spire short but pointed at the summit, whorls slightly coronated, aperture effuse, emarginate in front, columella smooth, outer lip with a wide but not deep notch at the suture."

This group corresponds to Nubecula of Klein, 1753; but owing to his being pre-Linnean and non-binomial, this designation cannot be accepted. Utriculus, of Schumacher, 1817, and Tuliparia, Swainson, 1840, are synonymous.

Cylinder was described on p. 391 of the same work.

"Shell sub-conic, smooth, spire elevated, pointed, whorls numerous, body whorl ventricose, notched at the suture, aperture effuse at the fore part."

Textilia, Swainson, 1840, is a synonym.

One of the difficulties to be contended with in working on the anatomy of tropical molluscs is the trouble in getting sufficient material, and in a good state of preservation. The two specimens here described are from the British Museum (Natural History), and had been there in spirit for a good many years, and I had started working on these before some recently collected specimens came to hand.

My thanks are due to J. Hornell, Esq., Pearl and Chank Fisheries, Tuticorin, for sending me specimens which I have

not yet worked out, also to E. A. Smith, Esq., I.S.O., of the Natural History Museum, for kindly allowing me to use some of the Museum specimens. My especial thanks are due to Prof. G. C. Bourne, Merton College, Oxford, for his kindly help and advice on many points connected with this paper, for which I am much indebted.

With the exception of Conus mediterraneus, which is found all round the Mediterranean and west coast of Spain, no other species inhabit European waters, though this large genus is plentifully represented in the tropical seas, and round the coasts of Australia, Japan and America. It generally lives in fairly shallow water, and is found on reefs and in pools under stones, corals, etc., and is supposed to be able to inflict a poisonous bite. I have made inquires from those who have collected and handled them alive. They tell me that they have never had this experience.[1] The animal is extremely timid; on the slightest touch it withdraws itself into its shell, and will remain in this retracted condition for a considerable time.

The operculum is generally elongate or unguiform, and so small that it is useless for closing the mouth of the shell when the animal has withdrawn itself inside.

The shells are covered with yellowish periostracum, which in some species is only a thin, smooth, transparent, but tough coating. In others, as in C. tulipa, the periostracum is exceedingly thick and of a dark-brown colour. It is rough, furrowed longitudinally, and of a leather-like texture, and has tufts or outgrowths disposed in even rows along its surface. When dry, this thick periostracum becomes very brittle and peels off the shell.

No doubt this shell covering, which, as I have said, in some species is tufted and of a leathery formation, is both a protection to the shell and also a form of protective coloration for the animal. C. tulipa has one of the lightest and

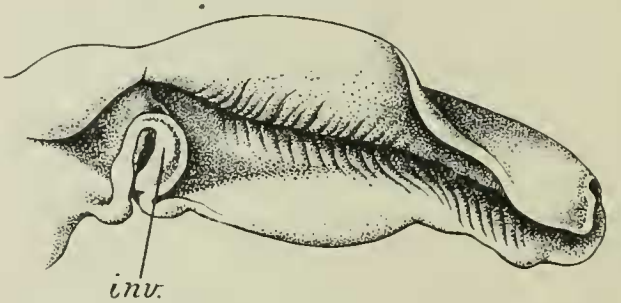
[1] While this paper was in the press, a note appeared in 'The Nautilus,' vol xxvii, pt. 10, pp. 117–120, 1914, "Poisoning by the Bite of Conus geographus."

thinnest of shells, and at the same time one of the thickest and most tufted periostraca. As the animal grows, and outer whorls are formed surrounding the inner ones, the walls of the internal convolutions of the shell are so reduced in thickness as to be hardly as thick as a sheet of paper, and semi-transparent.

Description of Conus Textile.

Maximum length of shell $2\frac{1}{4}$ in., maximum breath $1\frac{1}{8}$ in. Operculum long and narrow, and slightly reflected outwards

Text-fig. 1.



Conus textile. The siphon, with one side reflected to show ridges and furrows, and invagination (*inv.*).

at its anterior end. The foot, which is large and muscular, when withdrawn completely fills the opening of the shell. Along the internal edge of the foot (next the columella) is a row or ridge of large tubercles or nodules of a reddish-brown colour. The opening of the branchial cavity extends along the right-hand side of the animal, and the cavity is enclosed on its dorsal surface by a thin covering of membrane which along its outer or free edge is considerably thickened and muscular for a space of about $\frac{1}{8}$ in. This covering is attached at its posterior end to the body-wall, and has no attachment forward till it reaches the siphon, round which it is fused. It extends forward as a kind of flap beyond its point of attachment round the siphon, and overhangs the latter about $\frac{1}{8}$ in.

The siphon (Text-fig. 1) is large, and has thick muscular

walls which are folded over and form a funnel, open in front and beneath. The funnel is in the shape of a triangle, with its base above, and apex ventral, the apex being formed by the two free edges of the siphon, which run parallel and slightly to the right of the foot. The interior and dorsal surface of the siphon has a number of deep grooves and ridges running across and at right angles to its longitudinal axis, and also extending down its sides. They start near the anterior and free end, and continue about half its length backwards. At its junction with the body, the ventral edge of the left-hand fold of the siphon is sharply reflected upwards and at right angles into the funnel, forming a V-shaped invagination or elbow (*inv.*), which closes up more than half the passage, and fits into a depression in the foot.

The eyes are situated on the tentacles, about the middle, and on the outer side, this position being due to the tubercles on which they were borne having fused with the tentacles. The anterior end of the foot has a glandular groove running at right angles and across it, with a reflex fold above the groove. About a quarter of an inch behind this groove, and on the ventral surface, and equi-distant from both sides of the foot, is the orifice of the pedal gland, or pedal sinus.

When, as in Pl. 1, fig. 1, the branchial cavity (*br. c.*) is opened from above, with the siphon and buccal openings turned away from the observer, by cutting through the mantle (*ml.*) longitudinally and about three quarters of an inch to the left of the branchial opening, the ctenidium (*ct.*) is seen starting just behind the opening of the siphon (*si.*) into the branchial cavity, running backwards and across the latter in a curve to its dorsal attachment to the mantle, with the "fausse-branchie" on the right, and inside the ctenidium. The "fausse-branchie," or osphradium, is trifid, the result of specialisation from the more archaic form, where the osphradium is merely a filiform epithelial ridge. This specialisation is common to most of the Gastropod Toxoglossa.

Below the large branchial cavity, and separating it from the body-cavity, is a thin membrane or covering, which

gradually becomes thicker on each side, where it is attached to the body-wall. Immediately beneath this membrane, and at the posterior end of the body-cavity, lies a large yellowish mass, the poison gland (*p. g.*). Anterior to this latter are the numerous coils of the duct (*p. g. d.*) leading from the gland into the œsophagus (*œ.*); and anterior again to these and over-lapping them is the radula-sac (*r. s.*). The œsophagus is continued past the radula-sac and so to the mouth (*m. h.*).

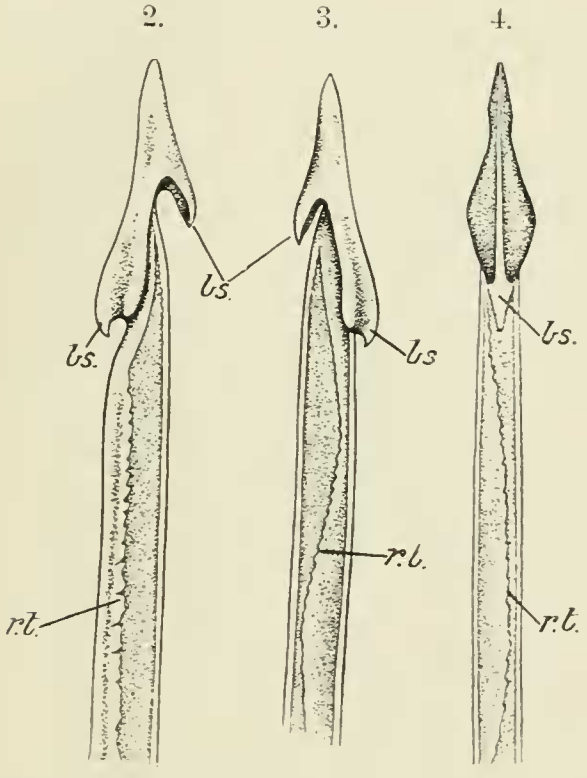
The duct of the poison-gland enters the œsophagus close behind the opening of the radula-sac, and passes backwards and to the right of the body-cavity, where it is twisted into a large coil. After leaving this coil it runs forwards and downwards parallel to the œsophagus, both it and the latter organ being surrounded by the nerve collars. Having passed backwards through the nerve collar, the duct is composed of very numerous and tightly twisted coils and knots, which are situated in front of and under the poison gland. The duct then straightens, passes to the right across the body-cavity, and enters the gland at its right-hand extremity. For about half an inch before the opening into the gland the duct is much constricted (Pl. 1, fig. 2). The whole of the poison duct is firmly bound together by connective tissue, which also surrounds the nerve collars and nerves given off from it, and binds all these organs tightly to the œsophagus. The poison gland (Pl. 1, fig. 2, *p. g.*) is a long narrow mass, nearly circular in section, pointed at each end, and slightly curved. It lies directly across the body-cavity with its two curved ends pointing downwards.

It is impossible to completely straighten out the numerous kinks and twists of the poison duct (Pl. 1, fig. 2) and so measure its length accurately, 270 mm. being as near as possible correct. The length of gland is 17 mm. and maximum width 5·5 mm. The length of the duct is about five times the total length of the animal, and the duct and gland together occupy the greater part of the body-cavity.

The salivary gland (Pl. 1, figs. 1, 2, *s. g.*) is a small yellowish, rather oval-shaped body, situated to the left of the body-

cavity, and in front of the poison ducts. It is provided with a pair of extremely fine thread-like ducts (*s. d.*), which open into the right side of the gland, one above and the other below. The lower one passes under the œsophagus, and the other above, and both enter the base of the V of the radula-

TEXT-FIGS.



The tops of teeth of Conus textile. *bs.* Barbs. *r.t.* Row of denticulations.

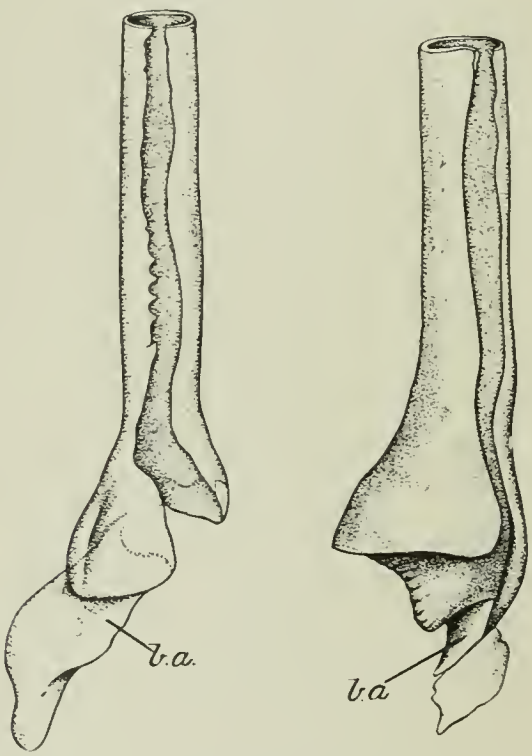
sac (*r. s.*), one above the other, as in the case of their gland-openings. These two ducts lie at right angles to the body axis.

The radula-sac is in the shape of a V; the right arm is elongated and about twice the length of the left, and ends in a cul-de-sac; the base is produced downwards and forms a knob, the left arm being the opening into the œsophagus. The long or right arm lies across the body-cavity and over the œsophagus, and behind the nerve collars. It is joined on the right by the left arm, which runs forward and downwards

where it joins the œsophagus. The long arm is slightly curved, and its length is 20 mm. The radula-sac is thick-walled and muscular.

The radular teeth (Pl. 1, fig. 4) are long, thin-walled tubes composed of chitin, and are very brittle, transparent, generally

TEXT-FIGS. 5 and 6.

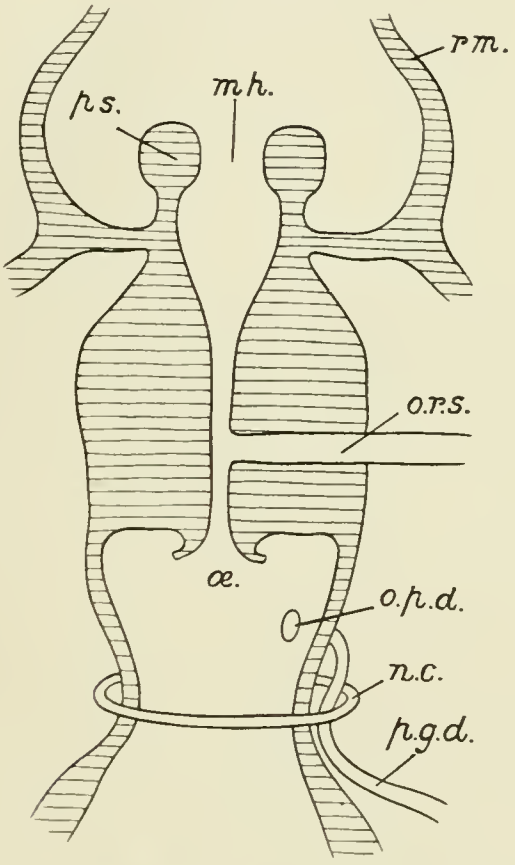


A view of the base of two teeth of Conus textile. *b.a.* Showing basal attachments.

light yellow, but sometimes quite dark. When placed in xylol to clear them for mounting purposes, they immediately underwent various contortions, tying themselves in knots and twisting into circles, etc. They are provided at their anterior ends with a flat lance-like point (Text-figs. 2, 3, 4), and on each side have a large and hooked barb (*bs.*), pointing backwards. The teeth are slightly curved and the barbs are placed one on each side of the curve, the one on the outside of the curve being about equi-distant between the one on the

inside and the lance-point. The average total length is 8–10 mm., and the diameter at the base, above the attachment, ·2 mm. The attachment varies a good deal in shape, but

TEXT-FIG. 7.



Conus textile. The base of rostrum, proboscis, mouth and œsophagus. *mh.* Mouth, *rm.* rostrum, *ps.* proboscis (with thick reflected lips), *o. r. s.* opening of radula-sac into œsophagus, *œ.*, *o. p. d.* opening of poison duct (*p. g. d.*) into œsophagus, *n. c.* nerve collars (only one represented). The shortness of the proboscis, and thick wall through which the radula-sac opens, will be noticed. (Diagrammatic.)

is generally a swelling of the base (Text-figs. 5, 6, *b. a.*), and thickened in parts. The points and barbs hardly vary at all. The lance-points in the radulæ I have seen, are not serrated as shown by Bergh (3), tab. vi, figs. 143, 144, 145. The radular teeth are placed in two groups in the radula-sac with their bases in the angle formed by the union of the two arms.

They are so arranged that one group have their barbs in the cul-de-sac of the long arm, while the points and barbs of the other protrude beyond the radula-sac opening, and into the œsophagus.

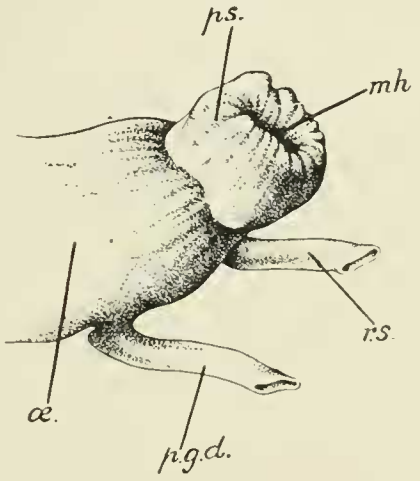
The teeth are fixed or anchored by means of an attachment or ligament which is firmly connected to their bases, and also to the wall of the radula-sac, but is of sufficient length to allow each tooth to move backwards and forwards. The teeth are placed in rows one behind the other for a short way up each side of the radula-sac but are all of nearly equal length, and are surrounded and connected with one another by a stout layer of connective tissue.

The rostrum (Text-fig. 7, and Pl. 1, fig. 1, *rm.*) is non-retractile, and forms what Gray (**10**) calls a veil ; it is thick-walled, muscular, and longitudinally ridged. The open or free end of the veil is provided with a single row of tentacles (*ts.*), by means of which the animal can attach itself to its prey. The posterior and internal wall of the veil is reflected forward, and, with the mouth (*mh.*), forms a retractile proboscis (Text-fig. 7, and Pl. 1, fig. 1, *ps.*). The edges of the mouth or lips are thick, ridged and corrugated and reflected internally (Text-figs. 7, 8). The retractile proboscis is in this species short, and after passing through the posterior wall of the veil, opens out into the œsophagus. The opening of the mouth is in the shape of a funnel (Text-fig. 7), the outer edge being formed by the thick lips, and as the cavity of the funnel narrows down internally, so the walls get thicker.

The œsophagus commences behind the posterior wall of the veil, where it immediately swells out, and as it increases in size, the funnel opening inside becomes smaller and the walls exceedingly thick and muscular, until at the base of the funnel only a very small passage to the mouth is left. These thick œsophageal walls end suddenly as though cut across at right angles just in front of where the œsophagus is slightly constricted owing to its being surrounded by the nerve-collars. The walls now become quite thin, with the result that the much constricted opening at the end of the funnel suddenly

opens out into a large cavity. The edge of this thick wall forms a ring or lip round the opening which hangs down into the cavity. The outside edge of the lip is reflected backwards, so forming a minute funnel. The radula-sac opens on the right (*o. r. s.*) in the thick-walled part, and the poison duct (*o. p. d.*) opens immediately behind it on the same side into the thin-walled cavity. Behind this last the œsophagus

TEXT-FIG. 8.



Conus textile. The proboscis and mouth showing thick reflected lips. The rostrum has been removed. *p. s.* Proboscis, *mh.* mouth, *r. s.* radula-sac, *p. g. d.* poison gland duct, *œ.* œsophagus (see diagrammatic, fig. 7).

is slightly constricted and the poison duct runs parallel and close to it, and both are surrounded by the nerve collars (*n. c.*). The œsophagus now expands into a large and thick-walled dilatation which corresponds to the stomach; it is nearly circular and passes backwards and dorsad of the liver (Pl. 1, fig. 1, *l. l.*). Here it narrows down, descends over the edge of the liver and turns with a sharp bend to the left, and so to the anus, situated at the posterior and right end of the recto-genital mass (*r. g. m.*). Where the stomach passes over the liver there is a large depression on the dorsal surface of the former, in which lies the left side of the poison gland.

The whole of the stomach, œsophagus and duct are pleated or corrugated, with the plications running parallel to their length, and the thick and deep ridges of the mouth are simply a continuation of these ridges in the œsophagus (Pl. 2, fig. 15).

Histology.

On account of the age and state of its preservation this specimen was not satisfactory for histological purposes. The sections were very hard to cut on account of the preparation being macerated, and were very difficult to stain. Various stains were tried, and those which gave the best results were Ehrlich's hæmatoxylin and eosin, but even with this method the nuclei were very badly defined, and in some cases were unstainable.

Poison Gland, or Glande de Leiblein (Pl. 2, fig. 9).

Down the centre of this gland runs a nearly circular canal (*ca.*). The poison duct opens into this canal at the right-hand extremity of the gland. The duct joins the gland in front and at right angles, so that the opening into the canal (Pl. 2, fig. 14, *o. p. d.*) is in reality to the side of one of its extremities and not at the end. A considerable portion of the coils of duct lies under and so ventral to the gland.

The canal in the gland is lined internally with non-ciliated epithelium (Pl. 2, fig. 9, *l. ep.*); this is surrounded by a thin ring of circular muscular-fibres (*c. m. s.*), external to which is a layer of longitudinal muscle-fibres and connective tissue (*l. m. s.*). This is again surrounded by another layer of circular muscular tissue (*c. m. s.*), of about a third the thickness of the preceding one. The last or external layer (*l. m. s.*) is about three times as thick as the other four layers taken together, and is composed of longitudinal muscular fibres and connective tissue. In the two layers of longitudinal muscles, i. e. the external and the middle layers, the muscle-fibres, though all running longitudinally and parallel to the length of

the gland, are disposed in bands of different depth and width so that they converge and overlap one another (Pl. 2, fig. 14).

These thick muscular layers forming the walls of the poison gland serve to eject the secretion along the duct to its opening in the œsophagus whenever its use is required.

Poison Duct (Pl. 2, fig. 10).

The wall of this duct is built up of two layers: an external layer (*l. l. m.*) of longitudinal muscular fibres and connective tissue, and an internal layer (*l. c. m.*) of connective tissue and circular muscular fibres. The internal layer is about half the thickness of the external one. The edges of these layers are well defined and do not merge into one another. This internal layer is again lined with a thick epithelium (*ep. cs.*), composed of very elongated club-shaped cells having basal nuclei which vary slightly in their position. The cells are filled with a fine granular substance. Interspersed among the cells of the epithelium are a number of granular vesicles. The club cells, which are extremely attenuated, are as much as ·2 m. in length. The average external diameter of the duct is ·65 m. An invagination of epithelium (*inv. ca.*) hangs down into the free passage of the duct. This passage or channel (*ca.*) along the centre of the duct is of a very irregular shape, having deep grooves or arms running into the epithelium.

The numerous coils of the poison duct are firmly bound together by connective tissue.

Stomach and Œsophagus (Pl. 2, fig. 15).

The stomach is nearly circular in section and the wall is of considerable thickness. The exterior layer (*l. l. m.*) is composed of longitudinal intermingled with a few transverse muscle-fibres and connective tissue. Beneath this layer and running into it is a complex network of transverse and circular muscular fibres (*l. c. l. m.*), intermingled with connective tissue and a few longitudinal fibres. Between this last layer and the thin coat of epithelium (*l. ep.*) lining the internal

surface of the stomach and œsophagus is a thick layer (*l. l. m*) of, for the most part, connective tissue and longitudinal muscle-fibres. In this there are a certain number of circular and transverse fibres disposed about the whole wall of the œsophagus and stomach, forming a complex mass of muscular fibres and connective tissue. These run to a certain extent in layers, one outside the other, and in some places are more distinct than in others, but have no definite margins, and merge one into the other.

The epithelium is in a very macerated state, but is not detached from the wall.

The projections or invaginations on the inner surface take the form of rounded lobes or ridges and have no very deep recesses between them.

The average external diameter of a transverse section is 2·75 mm., length 4 mm. Internal diameter of passage 1 mm., length 2·5 mm.

The sections were by far the worst of all, the stain hardly taking, nuclei being invisible.

Salivary Gland (Pl. 2, figs. 16, 17).

This gland is a small yellowish-white looking body which lies to the left of the œsophagus, and is connected with the latter by two very fine and twisted ducts, which enter at the base of the radula-sac. The maximum length of the gland is approximately 4 mm.

The two ducts (*s. d.*) opening into it are lined with cubical ciliated epithelium, and some little way after their entry into the gland branch off into two smaller ducts. These ducts are again split up into smaller ones, which in turn are divided up into still smaller ducts, so that the whole of the gland has a sponge-like appearance, and is composed of an extremely fine network of glands and ducts. The two main ducts enter some distance into the gland before receiving any branches.

In the ordinary way one would expect to find these minute glands grouped together in little bunches which empty into

one duct, and on account of their resemblance to a bunch of grapes are known as "acinous glands."

In the case of Conus textile, however, this is not so; the glands are unicellular, of various irregular shapes and sizes, placed side by side, and each cell has a separate duct (*dt. op.*), which empties into a larger one.

The cells are filled with a very fine granular substance (*g. c. c.*), which is secreted by their lining, and discharged through each individual duct (*dt. op.*) into larger ones, and so eventually finds its way through one or other of the main salivary ducts to the œsophagus.

This system of grouped unicellular glands is extremely rare, the acinous arrangement being much more common. Owing to the inferior state of the preservation of this material I have been unable to work out this point as minutely as I could wish.

Circulatory System of Conus Textile (Pl. 5, fig. 23, and Pl. 6, fig. 24).

Owing to my researches on the nervous system, and one specimen only being available, I have been unable to do much with regard to the blood circulation and supply. There is one artery (*g.*), the only one I have been able to follow out, which passes from the heart under the œsophagus in an oblique manner to the right. The artery is of considerable size, is oval in section, attached to the œsophagus by connective tissue, and passes forward with it through the nerve collars. The artery now leaves the under-surface of the œsophagus, passes to the right and across, anterior to the left pedal ganglion, to divide slightly to the right of the latter into three large branches, forming a cross, with its arms at right angles. The left branch (*x.*) passes to the base of the siphon, the central one (*y.*) plunges down to the anterior and central portion of the foot, while that on the right (*p. ft.*) proceeds to the extreme posterior and dorsal surface of the foot, along the right side of the latter, and only a short

distance below the external surface. About one quarter of its length from its posterior extremity a branch emerges from this last artery and passes downwards into the foot. There are no branches given off from the other two arteries, and in all cases they end abruptly. Just before the main artery passes through the nerve collar formed by the pleuro-pedal connectives, a right-angled branch is given off which is directed upwards. After a short space this branch is again divided at right angles, the one (*j.*) passing backwards. This latter runs parallel to the main artery (*g.*), and both are connected to the œsophagus, and, together with it, are surrounded by the pleuro-subintestinal collar. The branch artery, having passed backward for a short distance beyond this last nerve collar, is sharply reflected to the left and then turns forward again, forming a **U**, which in section is flat, and closely attached to the œsophagus. From its base and extremity three small branches pass over the surface of the œsophagus. The artery (*w.*) forming the right arm of the **T**, bifurcates, and its two branches are attached to the radula-sac on its ventral surface. Anterior to the nerve collars a large artery (*c. ft.*) proceeds from the main artery at the point where it leaves the œsophagus, passes to the right, across and dorsal to the pedal ganglia, and plunges into the centre of the foot, giving it the appearance of a pedal nerve. The arteries, as I have already stated, are in section oval or flat externally (Pl. 5, fig. 23), and are composed of an external sheath of areolar and circular muscular tissue, called "tunica adventitia" (*l.c.m.*), with an internal lining (tunica media) (*l.c.l.m.*) of circular and longitudinal muscular tissue. This last layer is internally coated with a thin lining of endothelium (*end.*)

Description of Conus Tulipa (Pl. 1, fig. 1).

Maximum length of shell 2 in., maximum breadth $1\frac{1}{8}$ in. Operculum oblong, small, and thinner than in C. textile. The foot is larger and wider, and the row of tubercles are not present; body-walls thick and muscular.

The siphon is the same as in C. textile, but has not the invagination or elbow, and is not so deeply ridged.

The rostrum is the same as in C. textile, having thick muscular walls which are corrugated and ridged throughout internally. There is also a single row of tentacles at the open end of the rostrum. This latter is in the form of a funnel with the constricted open end in front. The walls forming the base of the funnel are curved inwards to the centre, where they form a free and retractile proboscis (*ps.*) which is about two thirds the length of the rostrum, the mouth (*mh.*) being situated in the centre of the free end. The rostrum, which is annulate, has grooves and ridges of muscle running circularly round it on the outside, while internally these are lined with strong muscle bands attached to its anterior end and to its base, by means of which it can be exserted or contracted. The œsophagus (*œ.*) runs from the mouth back towards the stomach in the centre of the ring of muscle bands. The muscular bands are bound firmly to the walls and to the œsophagus by connective tissue.

The œsophagus, on its emergence from the posterior end of the proboscis, bends at right-angles to the right side of the body-cavity; it is then sharply reflected on itself (Pl. 1, fig. 3), becomes slightly larger, and passes back to the centre of the body-cavity, where it is constricted, and again takes a sharp turn to the right and back to the left. It now rapidly becomes larger, and the radula-sac opens on the right side, and the poison duct on the same side and slightly behind. Here it is again constricted, and, together with the poison duct, is surrounded by the nerve collars. The œsophagus now opens out into the stomach, which has the form of a flattened tube running from the centre backwards to the left, lying under the poison duct and gland on the floor of the body-cavity. The canal is again constricted, and passes over the dorsal surface of the liver (Pl. 1, fig. 1, *l. l.*), where it expands, and passes downwards and backwards over the back of the liver to the anus. The liver, a large brownish mass, lies on the left of the body and under the ctenidium (*ct.*). Where the stomach

passes over the liver, it has the same depression as C. textile on its dorsal surface; in this depression lies the left end of the poison gland (*pg.*).

The ctenidium is situated on the inside and dorsal surface of the mantle (*ml.*); starting in front and on the left side, it runs across the branchial cavity (*br. c.*) and then backwards, forming a semi-circle, lying above the liver.

The osphradium, or "fausse branchie," is, as in C. textile, trifid, being parallel to and on the right of the ctenidium, and runs backward about half its length.

The eyes are placed on tubercles which are fused with the tentacles in the same way as in C. textile, one on each side of the rostrum on its dorsal surface and on the external edges. These tentacles are situated about $\frac{3}{16}$ in. behind the opening of the rostrum.

The radula-sac (Pl. 1, fig. 3, *r. s.*) differs from that in C. textile in the fact that the left-hand arm of the V, which opens into the œsophagus (*œ.*) through a very constricted passage, is much shorter than in the latter species. Moreover, the right arm is curved in two places in the shape of an S, is shorter and thicker, and the base of the V, instead of being expanded so as to form a kind of bulb, in C. tulipa is very much larger and forms a sort of triangular hood (*h.*). The walls of the radula-sac are of about the same thickness and texture in both species, with this exception, that the hood-like process in C. tulipa is much thinner than the rest of the sac. The right-hand arm of the radula-sac lies above and across the œsophagus.

Immediately behind and above the radula-sac, and running across the body-cavity, are the coils of the poison duct (*p. g. d.*). These coils are much shorter and less twisted than in C. textile (Pl. 1, fig. 3). Behind them the poison gland (*p. g.*) lies athwart the body. The poison gland is about twice the diameter but shorter in length than that of C. textile. The poison duct enters the right extremity of the gland at right-angles in the same way in both species (Pl. 2, fig. 14). In C. textile it is constricted for about half an inch before its

junction with the gland, while in C. tulipa it is only constricted just at its entry (Pl. 1, fig. 3). The poison duct posteriorly to its opening into the œsophagus passes backwards through the nerve collars, and forms a large coil on the left of the body-cavity; it then passes across and in front of the gland to the right side, where there is another coil. From thence it passes under the gland and enters on the right. The length of duct after unravelling the coils is about 115 mm., or $2\frac{3}{10}$ times the total length of the animal. In C. textile the length of duct is 270 mm., or considerably more than twice as long. The length of the gland is 15·5 mm., diameter 8·3 mm., as compared to 17 mm. and 5·5 mm. in C. textile.

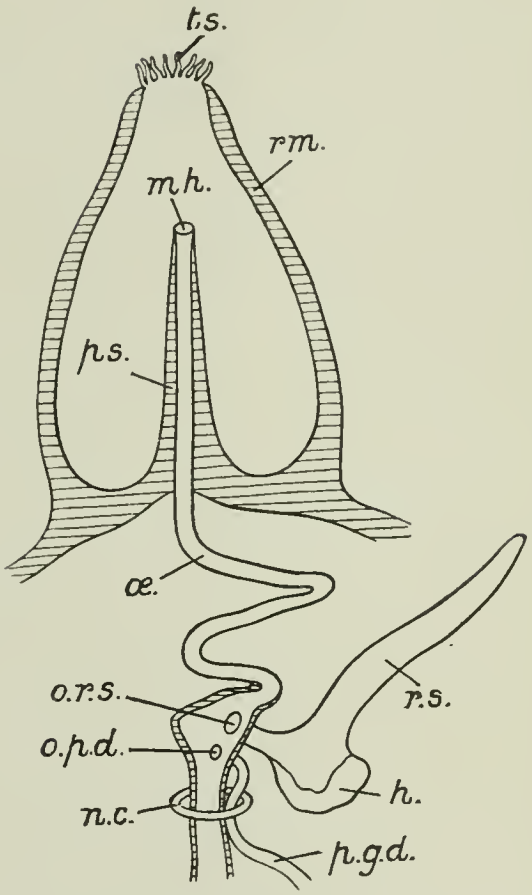
The salivary gland (Pl. 1, fig. 3, *s. g.*) lies to the left of the œsophagus and opposite the radula-sac. Its two fine and crenulated ducts (*s. d.*) pass in the same way, one above and one below the œsophagus, and enter the hood of the radula-sac one on each side, and above the nerve collars. The gland itself is larger than in C. textile.

This gland, called by Bouvier (**5**) the "glande impaire," is in this species in such a macerated condition that I have been unable to obtain any sections sufficiently good to warrant description.

There is considerable difference between the œsophagus and proboscis in C. textile and those in C. tulipa, as can be seen from the descriptions and figures of each. In C. tulipa the proboscis, which is conical and annulate, is two thirds the length of the rostrum ; the œsophagus runs down its centre, and the mouth is simply an opening at its anterior end. In C. textile the proboscis is quite short (Text-figs. 7, 8), and the mouth is provided with thick reflected muscular lips. The œsophagus is here simply a canal surrounded by thick muscular walls; while in C. tulipa it is a free duct surrounded by muscle-bands, which in turn are enclosed by the wall of the proboscis (Pl. 1, fig. 1), the ducts and muscle-bands only being held together and to the internal wall of the proboscis by connective tissue. Again, the distance in C. textile between the mouth and the opening of the radula-sac into the œsophagus

is short (Text-fig. 7), about a quarter of an inch, and the passage straight. In C. tulipa (Text-fig. 9) it is about four

TEXT-FIG. 9.



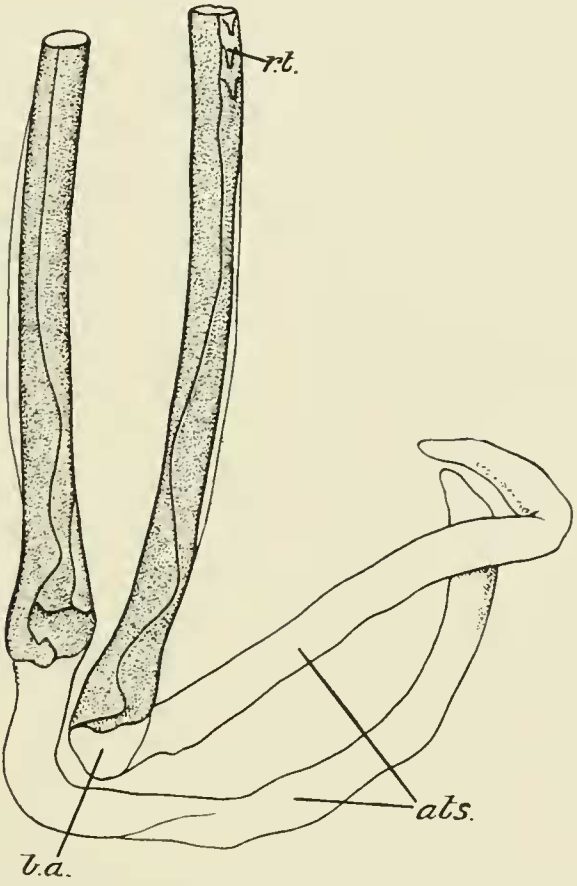
Conus tulipa. The rostrum, proboscis, œsophagus and radula-sac. *mh.* Mouth, *ts.* tentacles, *rm.* rostrum, *ps.* proboscis, *œ.* œsophagus, *r. s.* radula-sac, *o. r. s.* opening of radula-sac, *o. p. d.* opening of poison duct (*p. g. d.*), *n. c.* nerve collars, *h.* hood. The difference will be seen between this species and C. textile, in the length of proboscis and length of œsophagus between base of rostrum and opening of radula-sac into the œsophagus, which is thin-walled. (Diagrammatic).

times as long, or about one inch. The duct is also thin walled, and twice sharply reflected on itself. Lastly, the constricted funnel opening with its very thick walls suddenly emerging into a large cavity, is, in C. tulipa entirely absent. The radula-sac (*o.r.s.*) and poison duct (*o. p. d.*) in the latter species

simply open into the straight-walled œsophagus, which is here rather dilated.

Troschel (**20**, pl. vi, fig. 142) gives a drawing of the radula-sac, thick and short proboscis, and part of the œsophagus of

TEXT-FIG. 10.



The base of two teeth of Conus tulipa in natural position showing (*ats.*) attachments to wall of radula-sac. *b. a.* basal attachments, *r. t.* row of denticulations on side of teeth, *ats.* tooth attachment to sac-wall.

C. textile, which resembles my dissection of this species, though the œsophagus as shown by him is of greater size than I found to be the case in my specimen of the same species.

Whereas in C. textile (Pl. 1, fig. 2) the œsophagus and stomach for the greater part of their length are large, thick-walled and almost circular canals, being only constricted

where surrounded by the nerve collars, in C. tulipa (Pl. 1, fig. 3) the walls are thin, the duct is three times constricted, and never more than a third of the width of the former. In C. tulipa the canal is flat instead of round, and barely one tenth of the diameter of that of C. textile.

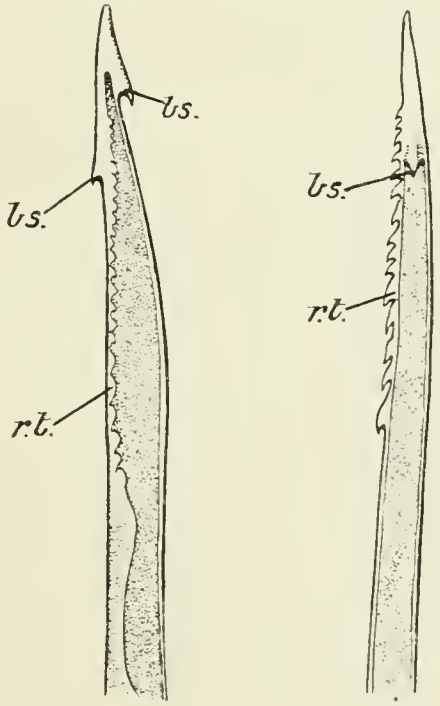
The radula-sac (*r. s.*) is, as in C. textile, thick-walled and muscular, but the length of the right arm is only 11 mm. as compared to 20 mm. in that species, and I have already given the difference in the shapes of the two sacs.

The teeth are placed in two groups, with the barbs or free ends of one group in the cul-de-sac of the right arm, those of the other group protruding through the œsophageal opening as in C. textile. At the base of each tooth, and firmly connected to it, is a roundish muscular attachment (Text-fig. 10) fixing the tooth to the wall of the radula-sac. Each attachment is generally about half the length of a tooth, and curves forward from its base in such a way that the other end is fixed to the sac wall on the side, and anterior to the base of the tooth. As in C. textile, the teeth are surrounded and connected together by connective tissue, and are generally hollow, and of a dark yellow colour. The anterior end of each tooth (Text-figs. 11, 12) is provided with a lance point, while on each edge behind this point is a hooked barb (*bs.*) pointing backwards, the barbs, as in C. textile, being so placed that the distance between the lance point and the first barb is the same as between the latter and the barb behind it on the other side. The point and barbs, though resembling those in C. textile, are, however, not nearly as large or stout, and the whole tooth is much straighter. The base (*b. a.*) is generally slightly swollen, and the chitinous walls are thicker than the rest of the tooth.

The teeth seem very constant in size and shape. On one side of each, and on the flat surface of the lance-point, and therefore at right angles to each of the two barbs, is a row of stout hooked denticulations (*r. t.*) with their points curved backwards and directed to the base of the tooth. These denticulations commence anteriorly about midway between the

two large barbs, and extend backwards in a row for about one third of the total length of the tooth. The denticulations vary in number from 15 to 25, and also in size in nearly every tooth, though 20 to 22 seems about the average number. In this respect the teeth of C. tulipa differ from those in C. textile,

TEXT-FIGS. 11 and 12.



11 12

The tops of teeth of Conus tulipa. *bs.* Barbs, *rt.* row of denticulations.

as the latter have not got this row of lateral denticulations. The average length of the teeth is 4 mm., or less than half the length of those in C. textile (8 to 10 mm.); while their diameter at the base above the attachment is the same in both species, viz. ·2 mm.

HISTOLOGY.

The state of this material, though better than that of C. textile, was not of the best, the specimen having been in

spirit for some considerable time. The same stains were employed as in C. textile, but again the nuclei were only partially defined.

Poison Gland.

As I have already stated, this gland occupies the greater part of the body-cavity and lies across it, with its right end slightly in advance. The canal runs down the centre of the gland, and the poison duct enters it from in front and at right angles at its right extremity in the same way as in C. textile (Pl. 2, fig. 14).

The canal (Pl. 2, fig. 7) (*c. a.*) is oviform, and lined throughout its interior with a thin layer of epithelium (*l. ep.*).

The wall of the gland is very thick and muscular (Pl. 2, figs. 6, 7, 8). It is composed of a deep external layer of longitudinal muscular fibres (*l. m. s.*), which run parallel with the length of the gland and form a thick sheath. Beneath this layer is a very much thinner layer (*c. m. s.*) (about one-sixteenth the thickness of the former) of muscular fibres running round the gland. A third layer (*l. m. s.*), in thickness about one third of the outer sheath, has the same composition as the outer sheath of longitudinal muscular fibres, and again runs longitudinally. Between this layer and the lining epithelium of the canal is a very narrow ring of muscle-fibres (*c. m. s.*) which run circularly round the gland. When compared to C. textile the poison gland is twice the diameter; the external sheath of longitudinal fibres is also twice as thick, the second layer is the same thickness, the third layer slightly deeper. The fourth or internal sheath of fibres running round the gland is about half the thickness, the epithelium is the same; the canal is one quarter the diameter, and oval instead of round. The muscle-fibres are disposed in the same irregular layers (Pl. 2, fig. 6) as in C. textile.

Poison Duct (Pl. 2, fig. 11).

The condition of these sections is not at all good, as the lining epithelium is very much macerated. The outer wall is

formed of a sheath of muscle-fibres (*l. l. m.*) which run parallel to the length of the duct; this is lined by a layer of fibres (*l. c. m.*) which run round the duct and are half the thickness of the external sheath. This last layer has an internal lining of epithelium (*ep. cs.*), which, as in C. textile, is composed of elongated club-shaped cells with basal nuclei. The cells, which are not as long or as fine as in the last species, are also filled with the same fine granular substance. The epithelium varies in length in different parts of the duct. The external surface of the poison duct in C. textile is circular, while in C. tulipa it is of a more irregular shape.

The whole of the centre of the duct is occupied by an irregular invagination of the epithelium (*inv. ca.*), which hangs down into the duct, and is connected by a restricted attachment to the lining epithelium. There is thus formed, with the exception of the place of attachment, an irregular circular canal (*ca.*) between the lining epithelium and the invagination. In the right side of this latter is a deep groove which runs in a curve upwards and then down to the centre. The average external diameter of the duct is ·65 mm., the thickness of the wall ·05 mm. and the epithelial lining ·02 mm.

In C. textile there is only a slight invagination hanging down into the centre of the duct, but owing to the epithelial lining being much thicker in this species (·2 mm.), the area of the canal is about one sixth of that in C. tulipa in spite of the invagination in the latter.

Stomach and Œsophagus (Pl. 2, fig. 13).

The œsophagus and stomach are in section oval externally with thin walls. Their internal surfaces are very deeply crenulated and pleated, forming large folds and furrows. This internal ridged surface is lined with columnar epithelium (*l. ep.*) of considerable thickness, which, as can be seen in the figure, has become detached from the muscle and connective tissue of the wall that surrounds it, this effect being due to its contraction in spirit, and where they are still

attached, the epithelium is distorted owing to its greater contraction and tendency to pull away from the outer layer. As far as I can ascertain from the sections (and, as I have previously said, the material is not of the best) the epithelium is non-ciliated, but appears to have the striated border which is characteristic of columnar epithelial cells. Embedded in this epithelial layer are a considerable number of what appear to be sporozoon parasites (*sp. pa.*). These are large, generally round or oval bodies, scattered all over the epithelium and buried in it at different depths. Some are so large as to extend through the whole depth of the layer, but never beyond into the muscle or connective tissue. In Ehrlich's hæmatoxylin they stain a deep purple colour, and in Heidenhain's hæmatoxylin a greenish-brown. It is impossible to say much about them with any accuracy, as they are extremely difficult if not impossible to define. From their appearance and the fact that they are clearly foreign bodies introduced into the epithelium, there is little doubt that they are parasites such as occur not uncommonly in Molluscs. The external layer of the œsophagus (*l. c. m.*) is composed of circular muscle-fibres which run round and ensheath it, intermingled with connective tissue and a certain number of longitudinal muscle-fibres. Beneath this layer, but very much confused and mixed up with it, is an imperfect sheath of longitudinal muscular tissue. Between this last and the epithelial lining of the œsophagus is a thick but irregular layer of longitudinal granular muscular tissue (*l. l. m.*), intermixed with transverse muscles and connective tissue which bind the epithelium to the œsophageal wall. In some places the epithelium has an internal lining of a granular appearance, while in other places it is wanting. No doubt this is a glandular secretion or mucus derived from the epithelial cells. The average external length of a transverse section is 1·6 mm. with width ·75 mm., the length of the œsophageal canal being 1·15 mm. and width ·15.

In C. textile the external length is 4 mm. and width 2·75 mm., length of canal 2·5 mm., width 1·0 mm. It will thus

be seen that all the measurements are far greater in C. textile than in C. tulipa.

In C. textile the wall of the œsophagus and stomach are thick, while in C. tulipa they are comparatively thin. In the former the canal is nearly circular, while in the latter it is oval.

In C. textile the lining epithelium is much thinner, and the internal surface, instead of being deeply crenulated and ridged, has large curved projections of the wall into the canal.

The eyes, as I have already mentioned, are situated on the internal edge of the tentacles, at the extremity of a small outgrowth produced by the fusion of the tentacle and tubercle. In both species they are identical, so I shall only describe that of C. tulipa, which is in the best state of preservation. The eyes are enclosed by a thin transparent membrane or outer corneal layer (Pl. 2, fig. 12, *co. o.*), which on each side of the eye is continuous with the coat of epithelium (*ep.*) covering the tentacle. Beneath the outer membrane is an inner corneal layer (*co. i.*), which is considerably thinner in front than at the back of the eye and composed of epithelium. This inner layer forms a hollow vesicle or eyeball, with a transparent cuticular lens (*le.*) occupying its interior. The optic nerve (*o.*), which is of considerable thickness, does not enter the retina, but expands out over the back of the eyeball and chiefly on the right side. As I have said, the inner layer of cornea is much thicker at the back of the eye, and is so modified that retinal cells (*ret.*) are formed in the epithelium, directed inwards to the hollow vesicle. These retinal cells run across the back of the eye, and round each side for a considerable distance, extending forward most on the right. These cells, which are embedded in pigment, are longest at the back of the eye, and gradually get smaller as they advance forward on each side, till they disappear posterior to the junction of the inner and outer corneal layers. The eye, which is highly developed as is the case in most molluscs, contains no points of special interest. The eye is easily discernible with the naked eye, appearing as a black spot on each tentacle.

Nervous System of Conus Tulipa.

I found that of the two specimens under discussion C. tulipa offered the most advantageous dissection for the nervous system, and I therefore described and illustrated this species first. As a complete description of the same system in C. textile would be for the most part simply a repetition of the former, though both have been equally carefully dissected, I shall content myself in C. textile with pointing out the differences which exist between the two species.

Description of the Nerve Centres of Conus Tulipa (Pl. 5, fig. 21).

There are thirteen nerve centres or ganglia, a right and left cerebral (*C.*), pleural (*Pl.*), buccal (*B.*), and pedal (*P.*, *P.* 1), a right (*V.* 1), left (*V.* 3), and median (*V.* 2) visceral, one sub-intestinal (*Si.*) and one supra-intestinal ganglion (*S.*). The ganglia with their nerves and connectives are of a whitish-yellow colour, and may be brought into prominence by treatment with osmic acid. The right and left cerebral ganglia (*C.*) are round in shape and fused together on their adjacent sides, and each is posteriorly united to the left and right pleural ganglia (*Pl.*) respectively, the right pleural ganglion being again attached on its posterior side to the supra-intestinal ganglion (*S.*). All these ganglia are extremely hard to define by reason of their junctions being indicated only by very slight constrictions and the whole being bound to the œsophagus by connective tissue. These ganglia lie on the œsophagus, where it is slightly constricted behind the opening of the radula-sac and poison duct. This position is seen in Text-fig. 9 (*n. c.*), but as this figure is purely diagrammatic, only one collar in the form of a ring, and without any ganglia, is shown. To the right, and slightly posterior, are situated the pedal ganglia (*P.*, *P.* 1).

These ganglia lie acoss the right side of the body-cavity under the radula-sac with their anterior extremities pointing

slightly forward. Both ganglia are closely connected together along their internal sides, being only distinguishable at both extremities, and more so at their anterior ends. The ganglia are slightly pyriform or attenuated anteriorly.

A cerebro-pedal connective (*ce. pl.*) passes from the left side of the left cerebral ganglion under the œsophagus, and enters the left pedal ganglia (*P.*) on its dorsal and posterior surface. The left pleuro-pedal connective (*pa. pl.*) runs under the œsophagus and parallel to and behind the cerebro-pedal connective, and joins the left pedal ganglion behind the latter. In like manner a right pleuro-pedal and cerebro-pedal connective passes over the œsophagus, connecting the right pedal ganglion (*P.* 1) to the right cerebral and pleural ganglia. The cerebro-pedal connective is smaller than the pleuro-pedal. Posterior to this last connective, and having their origins one in the left and one in the right pleural ganglia, are the pleuro-subintestinal connective (*d.'*) and the zygoneurous conective (*z.*) respectively of the visceral commissure (*d.*). The pleuro-subintestinal connective (*d.'*) issues, as I have stated, from the left pleural ganglion behind the left pleuro-pedal connective, passes in an oblique direction backwards and under the œsophagus, and enters the anterior and left extremity of the subintestinal ganglion (*Si.*). The zygoneurous connective (*z.*) issues from the same place in the right pleural ganglion, passes backwards and over the œsophagus, and enters the right anterior extremity of the subintestinal ganglion. This ganglion is pyriform, its attenuated posterior end forming the origin of the right loop of the visceral commissure (Pl. 4, fig. 19). The left pleural ganglion terminates posteriorly rather bluntly, being little attenuated, while the right ganglion, lying between the right cerebral and the supra-intestinal ganglia, is hardly distinguishable. This last ganglion, which is pyriform, is continued backwards, forming the left loop of the visceral commissure. This latter (*d.*), after leaving the ganglion, passes over to the left of the body-cavity, and through the wall where is situated the left visceral ganglion (*V.* 3). This ganglion ends abruptly

posteriorly, the commissure passing backwards till it reaches the median visceral ganglion (*V.* 2), which is placed across the body, anterior to the recto-genital mass, and is attenuated at both ends. The visceral commissure leaves the right extremity, passing forward and to the right, where it joins the right visceral ganglion (*V.* 1). This latter is pyriform anteriorly, while posteriorly it is produced where connected to a large nerve (*k.*) and the visceral commissure, the latter, after passing forward for some considerable distance, joining the anterior of the right visceral ganglion, with the posterior extremity of the subintestinal ganglion. The commissure is shortest between the median and right visceral ganglia.

From the anterior edges of both cerebral ganglia (Pl. 3, fig. 18, and Pl. 5, fig. 21) issue the cerebro-buccal connectives (*c. b.*). Both pass round the œsophagus, one on each side, and join the external edges of the right and left buccal ganglia (*B.*) respectively. These ganglia are small, circular, flat bodies lying under the œsophagus. They are united by two commissures, but are so close together that they appear almost to touch. The anterior commissure is of extreme fineness, while the posterior, which is of considerable stoutness, is the origin of the large buccal nerve (*s.* 5) which leaves the commissure close to the left buccal ganglion and passes backwards.

The œsophagus and the poison gland duct (Pl. 5, fig. 21) are completely surrounded by four nerve collars, with ganglia at each extremity of the collars, the most anterior being formed by the two cerebral and two buccal ganglia with their connectives. This collar is the smallest and lies close round the œsophagus, to which it is attached by connective tissue. Behind this comes the cerebro-pedal collar, and posterior again, the pleuro-pedal, these last two being larger and not so closely attached to the œsophagus, round which they lie obliquely, owing to the pedal ganglia being slightly behind the cerebrals and buccals on the right. The fourth and last nerve collar is the pleuro-subintestinal, and owing to the latter ganglion being situated still further backwards, this last collar is more oblique with regard to the œsophagus than the second and

third, but is smaller in circumference. The left half of this collar, which is the stoutest, is formed by the pleuro-sub-intestinal connective of the visceral loop (*d.'*), while the right half is the zygoneurous connective (*z.*).

The nerves issuing from the various ganglia, with the description of their functions and the parts they innervate, etc., will be dealt with under the various headings hereafter mentioned.

Tentacular and Optic Nerves (Pl. 3, fig. 18).

The tentacular nerves (*t.*), or, as they may be called, cephalo-tentacular, are the largest nerves given off from the cerebral ganglia (*C.*). They issue from the dorsal and anterior surface of the ganglia, that from the right supplying the right half of the rostrum, while the left side is supplied from the left ganglion. This left nerve, after leaving its origin in the ganglion, passes to the right, and is then sharply reflected back to the left, where, after proceeding a short way, a stout nerve (*t.* 1) is given off from its anterior side, which passes over to the left and is ramified, splitting up into numerous fine branches. Slightly anterior to the base of this nerve the main tentacular nerve is bifurcated, both nerves passing underneath it, the left branch (*t.* 3) being ramified in the same way as the preceding one. The right branch (*t.* 2) is subdivided into three, of which the median is the optic nerve (*o.*), while those on either side of it are divided up into numerous fine nerves like the other tentacular nerves.

The optic nerve, which, as has been shown, is only a branch of the tentacular nerve, is stouter than the branch on each side of it. When it reaches the place in the rostrum immediately below where the eye is situated, it turns at right angles through the rostrum wall and so to the eye.

The right tentacular nerve on leaving its ganglion passes to the right and slightly forward, where, after a short course, it is bent sharply backwards and then forward again, forming a kink. In the left nerve this kink is close to the left

ganglion, no doubt the duty of these two kinks being to allow a slight contraction or extension of the thick muscular walls of the rostrum. After its flexion or kink a fine nerve is given off on the inside of the right tentacular nerve, which supplies the rostrum base, and anterior to this latter the main nerve is bifurcated, the left branch again dividing into two, the left of these two (*t.* 1) being similarly split up. Both these last give off fine and very numerous branches on their course towards the tentacles, as is also the case with the right branch (*t.* 3) at the first bifurcation of the main nerve. The right branch of the second division of the main nerve (*t.* 2), after proceeding a short way, gives off a fine nerve, while the main nerve of these two, the left, is the optic nerve (*o.*), which proceeds to the eye in the same manner as the left optic nerve, and has two or three small branches issuing from it.

In his description of Conus virgo, Bouvier (5) says that the left optic nerve is given off from the tentacular nerve of the same side sooner than is the case on the right side. In my dissection of C. tulipa the reverse is the case, but, like Bouvier, I have been unable to ascertain whether the optic nerve is simply a branch of the tentacular, or whether, though both are in the same nerve-sheath, they really issue as two distinct nerves from the ganglia. The latter seems improbable, as in the case of the left optic nerve there are stout branches on each side supplying the tentacles, the optic nerve issuing from between them. All the tentacular nerves are extraordinarily ramified, splitting up and giving off very numerous fine branches. The ends of the nerves which supply the tentacles themselves, before entering the latter, are generally divided into at least three branches. Both the main tentacular nerves proceed from the ganglia under the base of the proboscis.

A most remarkable fact in connection with the nerve system of this species is the following: From the posterior surface of the base of the kink in the right tentacular nerve a stout branch (*t. p.*) issues; it runs backwards, and is much crenulated. This latter joins at right-angles a nerve (*r.*) running across the floor of the body-cavity, thus forming an inverted

T. The right branch is ramified, and supplies the base of the rostrum on the right, while the left branch proceeds to the dorsal surface of the right pedal ganglion, thus forming a connective between the tentacular nerve and the right pedal ganglion. This nerve, as far as I have been able to ascertain, has not been noticed before, and its presence is hard to explain.

There is no nerve or connective of any sort given off from the left tentacular nerve until the latter is bifurcated, as I have shown, the right branch passing forward to the rostrum and cephalic teguments.

Acoustic Nerves (Pl. 5, fig. 21).

These nerves are extremely fine and very hard to follow, on account of the great number of pedal nerves through which they pass. The origin of the left nerve (*ac. l.*) is in the left cerebral ganglion, immediately below the left cerebro-pedal connective, and between the latter and the left pleuro-pedal connective. This nerve runs between these two connectives to the left pedal ganglion (*P.*) along the anterior side of the latter, passing between numerous pedal nerves, then slightly backwards, and reaches the left otocyst (*ot. l.*) situated some little distance to the right and slightly posterior to the pedal ganglia. The right acoustic nerve (*ac. r.*) issues from the right cerebral ganglion at about the same place as does the left, but descends to the right pleuro-pedal connective, and runs along its anterior edge till both reach the right pedal ganglion (*P.* 1). The acoustic nerve, after following the posterior surface of the latter, passes along the pedal nerves backwards and to the right, till it reaches the right otocyst (*ot. r.*), which is situated in the muscles of the foot, and at a considerable distance from the pedal ganglia and behind them.

Proboscidean Nerves (Pl. 4, fig. 19).

The nerves to the proboscis, or labio-proboscidean nerves, are three in number on each side, and issue from the anterior

edges of the cerebral ganglia. The nerves are stout, of a white colour, not deeply imbedded in the muscular wall of the proboscis, and run parallel to the œsophagus and at about equal intervals round it, the central one (*l.* 1) being on the ventral surface. The two central nerves (*l.* 1) are the longest, and have the fewest nerves given off along their length, and are the finest and most crenulated of the three sets. They run to the anterior end of the proboscis, and are here broken up into a number of fine nerves. The second pair (*l.* 2) are straighter, and the left member of the pair gives off a large branch about one third of its length from the ganglion, while in the right nerve the branch is half-way. The left nerve of the pair (*l.* 3) is trifurcated, the right one bifurcated, all branches being much ramified. In section these nerves are nearly flat and much crenulated.

The walls of the rostrum and cephalic tegument are supplied by three pairs of nerves (*l.* 4–*l.* 6) as well as by branches given off from the tentacular nerves. As was the case with labio-proboscidean nerves, these nerves to the rostrum are in three pairs, and have their origin in the anterior part of the cerebral ganglia (*C.*). The three pairs are nearly the same size, but are very much finer and shorter than the three pairs of labio-proboscideans. As was the case in Bouvier's dissection of C. virgo, so in this species, the first pair of nerves (*l.* 4) go to the base of the rostrum wall, where they are ramified and run forward, while the other two pairs on the right (*l.* 5, *l.* 6), which are slightly finer, pass from the cerebral ganglion across the cerebro-pedal connective, and so enter the muscular wall of the rostrum, where they run anterior to the first pair (*l.* 4). Before they enter the muscular rostrum wall, and between here and their ganglia, the nerves (*l.* 5, *l.* 6) are very sinuous, as is the case more or less with all the nerves to the rostrum and also the labio-proboscideans. This is due to the fact that nerves, being non-extensile or retractile, or nearly so, when they enter a wall which may be exserted or contracted, as in the case of the proboscis, and slightly so in the rostrum, are supplied with enough slack nerve between the ganglia and

their entry to allow the wall to be fully extended without pulling on the nerve. When fully contracted or abnormally so, as in spirit, the nerves have a very sinuous appearance.

Buccal Ganglia and their Nerves (Pl. 3, fig. 18).

The buccal ganglia (*B.*) are small, circular, flat bodies which lie under the œsophagus, and their external edges are joined by a stout connective to the anterio-dorsal surface of the cerebral ganglia (*C.*). The two internal and adjacent edges of the buccal ganglia are connected by two sub-œsophageal commissures, but the ganglia are so close together that they almost touch, the commissures being about a sixteenth of an inch long. The anterior of the two is extremely fine, while the posterior one is as stout as the cerebro-buccal connectives (*c. b.*). These two ganglia, therefore, with their connectives, form a complete nerve collar round the œsophagus, the buccal ganglia being slightly posterior to the cerebrals. The openings of the radula-sac and poison duct into the œsophagus are anterior to the nerve collar.

For the sake of comparison I have used the same letters as employed by Bouvier in his figures. From the posterior surface of the right buccal ganglion a nerve (*s.* 1) is given off, which innervates the anterior portion of the poison duct, till a branch is given off to the latter from the main poison-gland nerve. There is no corresponding nerve given off from the left ganglion. The buccal proboscidean nerve (*s.* 2), which is anteriorly ramified, supplies the wall of the œsophagus in the proboscis, the wall of the proboscis being innervated from the cerebral ganglia by the labio-proboscidean nerves. Here, in like manner, I have been unable to find any such nerve issuing from the left ganglion, nor was I able to find the nerve mentioned by Bouvier as being given off by the side and proceeding to the œsophagus.

Two pairs of nerves (*s.* 3, *s.* 4), one pair issuing from each ganglion, supply the wall of the radula-sac, those given off from the right ganglion supplying the dorsal surface of the

sac, while the two from the left ganglion supply the ventral surface. The main nerve (*s.* 5) which innervates the poison gland and duct, issues from the posterior commissure, and runs backwards under the œsophagus and through the nerve collars. This nerve, which is of considerable size, after passing backwards for some distance curves to the right, where a branch is given off which supplies the poison duct and takes the place of the first fine nerve (*s.* 1). The main nerve now doubles back to the left and then again to the right, three or four slender nerves being thrown off to the coils of duct among which the main nerve runs. This nerve, after passing to the right, is trifurcated, the three branches being ramified and supplying the walls of the poison gland, the branch to the right entering the right extremity of the gland by the duct opening. After the main poison gland nerve has passed backwards from the buccal commissure, a fine nerve (*s.* 6) is given off on the left, which runs backwards along the wall of the œsophagus and is much ramified. The existence of this nerve was indicated by Bouvier (5) p. 341, where he says: "Dans un individu femelle, il me sembla qu'un filet grêle se rendait de ce nerf a l'œsophage, en arrière des colliers nerveux." About this point he was not certain, and mentions the difficulty experienced in removing the connective tissue which completely surrounds and binds firmly together the nerves, the œsophagus, and coils of poison duct; this I also found most troublesome, but managed to free the nerve, and ascertained that this nerve (*s.* 6) does run from the main nerve to the œsophagus. As stated by Bouvier, the main nerve (*s.* 5), on account of both its position and origin, would correspond to the œsophageal-aortic nerve in Buccinum, if a branch was given off to the œsophagus, and this I have shown to be the case.

Left Pleural Ganglion and Nerves Issuing (Pl. 4, fig. 19).

This ganglion is attached to the posterior end of the left cerebral ganglion, the end of the one and the beginning of

the other being only distinguished by a slight constriction between them. The posterior extremity of this pleural ganglion (*Pl.*) is directed slightly to the left, while the ganglion is very slightly pyriform and attenuated posteriorly. On the left, and from the external and ventral surface, a stout connective (*d.'*), the pleuro-subintestinal connective of the visceral commissure, issues, turns to the right, across the floor of the body-cavity, runs slightly backwards and under the œsophagus, and enters the ventral and anterior end of the sub-intestinal ganglion (*Si.*).

Two columellar nerves (*i.* 1, *i.* 2) are given off from the centre of the ventral surface of this pleural ganglion, while none are present in the corresponding right ganglion. The nerve on the right (*i.* 2) passes backwards and slightly to the right, being much crenulated and unattached to the body-cavity till it splits into four fine nerves, which diverge in the columellar muscle. The left of this pair (*i.* 1) is twice the size of the former, being sinuous or crenulated in the same way, and runs directly backwards, being unattached to the wall for some considerable distance. Shortly after its entry in the wall it is bifurcated and descends almost vertically into the base of the columellar muscle on the right, and about level with the left visceral ganglion (*V.* 2). Both nerves pass under the œsophagus, the left one running parallel with it, and supply the anterior and left half of the columellar muscle and base of the body-cavity. These two nerves differ from those in Conus virgo, described by Bouvier (5), in the following respects; they are shorter, supply the columellar muscle anteriorly and to the left, instead of posteriorly and on the right, do not pass through the nerve collars or go anywhere near the right pleural ganglion or the sub-intestinal, but are absolutely distinct and run directly backwards from their origin.

Four nerves are given off from the postero-dorsal edge of the left pleural ganglion, two being parietal, the other two being the main and lesser pleuro-siphonal nerves.

The most anterior of these four (*f.* 1) is the lesser pleuro-

siphonal nerve, the second (*f.*), the main pleuro-siphon, the third and fourth (*c.* and *c.* 1) being parietal. All these four nerves, after leaving their origins in the ganglion, pass directly to the left, being suspended and quite unattached for some considerable distance between the ganglion and their entries into the base of the body-wall. The lesser pleuro-siphonal nerve passes through the base of the rostrum and at once runs downwards over the attachment of the base of the siphon to the base of the rostrum. When it reaches the siphon proper it gives off two or three small branches and passes forward along the left siphonal wall. The main siphonal nerve (*f.*), which is very much larger, runs parallel but posterior to the former till it reaches the base of the siphon, where it proceeds along the centre of the channel and gives off fine nerves which run into the walls on both sides. When one third of the length from the anterior extremity of the siphon, the main nerve is trifurcated, each branch ramifying in the sides and extremity. At its entry into the base of the siphon, a stout anastomosis (*a.*) connects it with the anterior branchial nerve (*b.*).

The parietal nerve (*c.*) enters the floor of the body-cavity on the left, just behind the main pleuro-siphonal nerve, giving off fine branches to the floor and wall. The other nerve of this pair (*c.* 1) issues from the ganglion behind the former, and after a short distance passes forward under it, and also beneath both the pleuro-siphonal nerves, entering the body-wall anterior to the foregoing. Both parietal nerves are by far the finest of the four nerves given off from this ganglion.

Supra-intestinal Ganglion and Nerves (Pl. 4. fig. 19).

This ganglion (*S.*), which is closely connected to the posterior extremity of the right pleural ganglion, serves as origin for six nerves. There is hardly any constriction at the junction of the two ganglia, which are, therefore, hard to distinguish in a dissection. The supra-intestinal ganglion is pyriform in shape with its posterior extremity directed slightly

to the left. Bouvier (**5**) mentions only four nerves as coming from this ganglion; of the two additional nerves that I have recognised, one is only a parietal nerve and of little or no importance; the other will be mentioned in due course.

There are, then, as I have said, six nerves from this ganglion, two being parietal, two branchial, one, the largest, the supra-intestinal branch of the visceral commissure, and the last supplying the inner edge of the branchial cavity. All these six nerves lie above the two columellar nerves (*i.* 1, *i.* 2).

All the nerves issue from the posterior extremity and dorsal surface of the ganglion, the most anterior being the main branchial nerve (*b.*), which is the stoutest of the six with the exception of the supra-intestinal branch of the visceral commissure.

The main branchial nerve (*b.*), after leaving the ganglion, passes slightly backwards and to the left of the body-cavity where it enters the wall running forward and parallel to the pleuro-siphonal nerve (*f.*). In front of and above the anterior end of the liver these two nerves come closer together, and, as I have already stated, a stout anastomosis (*a*) connects them before the branchial nerve reaches the mantle. The branchial nerve is now reflected sharply to the left and passes under the extreme anterior edge of the osphradium and ctenidium, supplying fine nerves to each; the main nerve ramifies in front and to the left of the ctenidium, and forms a fine network, with numerous anastomoses, in the mantle. Slightly to the left of where the branchial nerve lies above the left columellar nerve (*i.* 1), a stout branch (*b.* 1) is given off which runs parallel to and almost touches the main nerve for some considerable distance. After passing down through the body-wall this branch lies across the anterior lobe of the liver, whence it proceeds backwards and under the edge of the osphradium, supplying this and the central portion of the ctenidium.

The posterior branchial nerve (*b.* 2) is much finer than the anterior, and crosses over to the mantle behind the branch of the main branchial nerve which I have just described, being

practically parallel to it throughout its length. Having passed under the posterior end of the osphradium and given off two or three fine nerves, the main portion of the posterior branchial nerve innervates the internal portion of the mantle and the posterior parts of the ctenidium. According to Bouvier the nerve with its fine branches and anastomoses supplying the anterior edge of the mantle is given off after the anastomosis (*a.*) between the anterior branchial nerve (*b.*) and the main pleuro-siphonal nerve (*f.*), and is thus a product of the pleuro-siphonal nerve. In my dissection this is not so, for the branchial nerve bifurcates, the right branch, which is the finer of the two, forms the anastomosis (*a.*), while the left branch supplies the anterior portions of the mantle in addition to the ctenidium and osphradium, so that this nerve, which in both cases supplies the anterior mantle edge, is in my dissection not pleuro-siphonal but branchial. The branchial nerve, therefore, is of much greater length than that figured by Bouvier.

Another curious point and one worthy of note is the presence of the large branch (*b.* 1) issuing from the main branchial nerve close to its origin. At first sight I was under the impression that this was the posterior branchial nerve, but closer inspection soon proved that this was not the case, for it is undoubtedly simply a branch of the anterior nerve, the posterior branchial nerve (*b.* 2) being quite distinct and originating to the right of the former. The typical position for the posterior banchial nerve would be slightly behind this branch nerve, though not as far back as it is in this specimen.

There are, therefore, according to the parts they innervate, three, and not two branchial nerves. The main and anterior nerve is normal; its branch forms a median branchial nerve; the posterior nerve proper is displaced backwards, and with the aforesaid branch, innervates rather more than the area covered by a normal posterior branchial nerve.

There is nothing of much interest about the two parietal nerves (*c.* 2, *c,* 3). Both cross over to the left and supply the body-wall. The anterior (*c.* 2) leaves its ganglion between

the anterior and posterior branchial nerves, while the posterior (*c.* 3) has its origin between the visceral commissure (*d.*) and the posterior branchial nerve. Soon after its entry in the wall, this posterior parietal nerve expands out into a small, ganglionic-looking mass, from which two fine nerves run forward and three backwards into the body-wall.

The four parietal nerves, two from the left pleural ganglion (*c.*, *c.* 1) and two from the supra-intestinal ganglion (*c.* 2, *c.* 3) innervate the body-wall and side, anterior to the left visceral ganglion (*V.* 2).

The sixth nerve (*c.* 4), which I have mentioned, leaves the supra-intestinal ganglion on its right and postero-ventral edge, runs backwards and to the left, and plunges into the body-wall just in front of the left visceral ganglion, and after running down through the wall, emerges above and passes across the liver to the mantle base, where it ramifies and supplies the mantle wall between the hinder portion of the ctenidium and the base of the mantle. This nerve is not noted by Bouvier in C. virgo, but in the specimen under discussion it is as stout as the posterior branchial nerve, and from its position is of some interest.

The remaining nerve, issuing from the supra-intestinal ganglion, is the left or supra-intestinal branch of the visceral commissure; this I shall discuss with the visceral ganglia.

The Visceral Commissure and Ganglia (Pl. 4, fig. 19).

There are three visceral ganglia. The left one (*V.* 3) is situated in the body-wall near the anterior portion of the liver and above it on the right side. The right ganglion (*V.* 1) is found in the wall enclosing the posterior part of the body-cavity and near its left extremity, while the median visceral ganglion (*V.* 2) lies to the right of the posterior part of the liver, and in front of the recto-genital mass (*r. g. m.*)

The left branch of the visceral commissure (*d.*) has its origin in the posterior and dorsal surface of the supra-intestinal ganglion, passes obliquely backwards and to the left, and so

into the body-wall, and enters the left visceral ganglion close to the right edge of the liver. From the ventral surface of this ganglion, two nerves issue, which might equally well be called parietal or columellar nerves, since they supply the walls and columellar muscle to the right and below their ganglion and almost touch the left columellar nerve (*i.* 1) which issues from the left pleural ganglion. The commissure, after leaving the left ganglion, runs backwards and downwards and slightly to the right, where it meets the median visceral ganglion. Between these two last ganglia, and about one third of the distance from the left visceral, a nerve (*n.*) issues from the left side of the commissure, and runs through the base of the mantle to the dorsal surface of the liver. This hepatic nerve turns to the right and passes back through the dorsal and right edge of the liver and emerges on the right side, where it is trifurcated. The commissure itself does not run out in a loop over the dorsal surface of the liver, but is more normal, being situated in the thick tissue formed by the junction of the mantle to the body-wall, and is thus on the extreme right edge of the liver. The hepatic nerve (*n.*), which I have just described, is peculiar both from its origin and from the fact that it is of considerable size, and the only nerve I have been able to trace which supplies the liver from the commissure. Bouvier mentions the existence of a fine hepatic nerve in C. virgo.

The median visceral ganglion is not so large as the left visceral. Three nerves issue from it; that to the left (*m.*) supplies the posterior lobe of the liver, while the central nerve (*m.* 1), which is the largest of the three, is the visceral nerve, innervating the heart as well as the genital organs and kidney. The nerve on the right (*m.* 2) is the genito-rectal nerve. Between the median and right visceral ganglia, two parietal nerves are given off to the body-wall from the commissure, which latter, after leaving the median ganglion, passes forward and to the right, and so to the right visceral ganglion. One nerve (*k.*) arising from this last ganglion (*V.* 1) is of considerable size. As stated by Bouvier, this nerve is pleural,

and issues from the posterior and right side of the ganglion, passes backwards and into the mantle, beneath the recto-genital mass and up over the back without entering it, where it again reaches the mantle, turns sharply to the right and is ramified.

After leaving the anterior end of the right visceral ganglion, the visceral commissure runs forward and to the right through the body-wall till it reaches the posterior portion of the body-cavity. Here it emerges from the body-wall under the poison gland and duct, where it enters the hindmost part of the sub-intestinal ganglion. I have been unable to find any nerves issuing from the left visceral ganglion and passing to the liver as indicated by Bouvier.

Sub-intestinal Ganglion (Pl. 4, fig. 19).

This ganglion gives off five nerves, four of which innervate the right part of the body, while the fifth is the visceral commissure. All these five nerves are unattached, and lie on the floor of the body-cavity till they enter the posterior wall of the latter.

The ganglion (*Si.*) is pyriform and attenuated posteriorly and slightly to the right, the visceral commissure (*d.*) entering the posterior extremity. One nerve (*e.*) issues from the left and ventral surface of the ganglion, passes backwards and slightly to the left, and enters the body-wall under the visceral commissure, where, after its entry, it divides up into numerous fine branches. The branches supply the body-wall as well as the posterior muscles of the latter, which eventually unite with the columellar muscle, so that this nerve, though really parietal, is in part also a columellar nerve.

There are two true parietal nerves given off from the ventral and right side of the sub-intestinal ganglion, both being finer than the nerve just described, and lying to the right of it. Both these nerves (*e.* 1, *e.* 2) supply the hinder portions of the body on the right, as also part of the right side, but do not extend as far back as the parietal-columellar

nerve. The right of these two nerves (*e.* 1) issues from its ganglion more anteriorly than does the left. Between these two and starting more from the right side of the ganglion is the largest of the four nerves, the right pleural nerve (*e.* 3). This nerve passes backwards and slightly to the right, running at no great depth through the body-wall till it reaches the thick muscular ridge formed by the posterior edge of the body-wall and bounding the anterior side of the anal channel. On reaching this ridge, the nerve plunges straight down and under the channel and to the right, where the nerve divides into two, the left branch running back and ramifying in the edge of the mantle to the right, while the right branch, curving forward again, supplies the under-surface of the body by its junction with the mantle. The zygoneurous connective (*z.*) unites the right pleural ganglion (*Pl.*) with the sub-intestinal ganglion (*Si.*). It is of considerable stoutness, and issues from the ventral and right side of the former to pass backwards and to the right, and is then bent abruptly posteriorly and enters the sub-intestinal ganglion anteriorly and on its dorsal and right side. This connective passes over the œsophagus, while the pleuro-subintestinal connective (*d.'*) of the visceral commissure is sub-œsophageal.

There are no nerves given off from the right pleural ganglion, the right side of the body being innervated from the sub-intestinal ganglion. Bouvier, in his figures and text, has confused these two connectives, since he calls that between the left pleural ganglion and the sub-intestinal ganglion the zygoneurous connective, while he describes the one between the latter and the right pleural ganglion as the connective of the visceral commissure, whereas it is exactly the reverse.

Pedal Ganglia (Pl. 4, fig. 20, and Pl. 5, fig. 21).

These two ganglia are so closely connected together that they look like one irregular ganglion. On closer inspection it will be noticed that at both anterior and posterior extremities there is a slight cleft or constriction between them, which is

most distinct at their anterior end. The ganglia lie under the radula-sac on the floor of the body-cavity and are inclined so that their anterior ends are slightly lower than the posterior. The ganglia are so displaced that they lie across the body-cavity instead of their longitudinal axes running parallel to the foot, the anterior extremities being slightly in advance of the posterior, the ganglia thus lying at a tangent to the longitudinal body-axis and considerably to the right. From this it will be noticed that owing to torsion, the symmetry of the anterior part of the body has been entirely displaced. Of this not only the pedal ganglia but also the otocysts bear witness, for the latter are not really right and left, but anterior and posterior, the right (*ot. r.*) being practically directly behind the left (*ot. l.*), and both are situated at the base of the foot and on the right side. Each of the two pedal ganglia is connected with the cerebral and pleural ganglia of its own side by the cerebro-pedal and pleuro-pedal connectives. The cerebro-pedal connectives join the pedal ganglia anteriorly to the pleuro-pedals, the latter being the stoutest of the two pairs. These connectives with their ganglia form two complete and wide nerve collars round the œsophagus and lie obliquely round the latter, since the pedal ganglia are to the right, and slightly posterior to the cerebral and pleural ganglia.

The nerves given off from the pedal ganglia are extraordinarily numerous, and for the most part of considerable size. They issue from the sides and anterior extremities of the ganglia. The posterior part of the foot is innervated from the right ganglion, while the anterior half is supplied from both right and left ganglia, the right ganglion sending nerves to the anterior and right half, the left ganglion to the left anterior portion.

There are many more nerves issuing from the right ganglion than from the left, the former giving off thirty, while only eleven proceed from the left ganglion. As I have already stated, most of these nerves are of considerable size, some—8, 9, 14, 29—equal in stoutness the tentacular nerves;

thus the foot and right side of the body are very highly innervated.

I do not propose to describe all these forty-one pedal nerves, but they will be seen in Pl. 4, fig. 20, and the parts they supply are described in the explanation of that figure.

The following nerves are worthy of a passing note. The posterior portion of the foot is supplied from the right ganglion by the nerves 29, 31 and 32, of which the first is the stoutest while the latter pair run side by side for most of their length. The right ganglion also innervates the central and ventral parts of the foot, with the exception of the one bifurcated nerve 23, which proceeds backwards from the left ganglion, while the chief nerves from the right ganglion are 25, 27 and 28.

There are three main nerves to the anterior region of the foot, of which 8 and 9 issue from the ventral and anterior side of the left ganglion, and supply the left side, while 14 passes to the right side from the anterior edge of the right pedal ganglion. An anastomosis exists between this nerve and the smaller nerve 13.

One very sinuous nerve (1) after leaving the anterior and ventral surface of the left ganglion, passes under the œsophagus and cerebro-pedal and pleuro-pedal connectives, directly over to the left side, and enters the floor of the body-cavity immediately in front of the left columellar nerve (*i.* 1), where it is trifurcated and innervates the floor under the left pleural ganglion. A fine nerve, 41, issues from the ventral surface of the right ganglion, and supplies the cavity floor directly beneath the pedal ganglia.

From the foregoing account of the nervous system of this species, several points of interest will be noticed, some new, and others confirming the descriptions of previous writers on this genus. Among the latter is evidence of the existence of an œsophageal nerve given off from the poison gland nerve, and indicated by Bouvier. Both my dissections have been of females, as was Bouvier's, and I have not yet been able to dissect a male of either species owing to lack of material.

Perhaps the most interesting feature about the nervous system of the above species is the connection between the right tentacular nerve with the right pedal ganglion, by means of a branch uniting the former to a nerve passing to the body-wall from the right ganglion.

Differences between Nervous Systems of Conus textile and Conus tulipa.

The nerve centres are situated in similar positions in both species; in C. textile both the centres and their nerves are of a reddish-yellow colour. The cerebral, pleural and supra-intestinal ganglia are more closely connected, and even harder to differentiate. The internal edges of both pleural ganglia almost meet, and the constriction is hardly noticeable between the cerebral ganglia, while the whole mass is covered by a thick sheath of connective tissue. The supra-intestinal ganglion is connected, as in C. tulipa, to the right pleural ganglion, their junction being hardly determinable, while the posterior extremity of the former is directed sharply to the left, from whence the left-hand loop of the visceral commissure issues. This flexion of the ganglion is so abrupt as to bring the posterior portion immediately behind the left pleural ganglion, with the result that, at first sight, there appear to be two supra-intestinal ganglia.

The visceral commissure and nerves issuing from the supra-intestinal ganglion, owing to its peculiar shape, proceed across the body-cavity to the left, and at right angles to its axis, instead of obliquely backwards as in the former species. The left pleural ganglion is more pyriform, but in other respects is the same. The positions of the ganglia lying around the œsophagus and also of the sub-intestinal ganglion are similar, but the pedal ganglia lie further back than in C. tulipa, and are not so attenuated anteriorly. These last ganglia are attached with the cerebral and pleural ganglia by the usual pairs of connectives, the anterior, the cerebro-pedal, being very much finer than the pleuro-pedal con-

nectives. Both run parallel and close alongside of each other entering the sides of the pedal ganglia, and issuing close together from the posterior and external edges of the cerebral ganglia and the anterior edges of the pleural ganglia. The pleuro-subintestinal and the zygoneurous connectives are of about equal size. The right visceral ganglion, to which the former proceeds, is not pyriform, but of an oblong shape, and the connectives enter at the opposite extremities on the anterior surface. The three visceral ganglia are situated in about the same positions, but the commissure connecting them is shorter. This latter has its origin in the posterior and left side of the sub-intestinal ganglion behind the entry of the pleuro-subintestinal connective.

The buccal ganglia are attached to the cerebral ganglia in the same manner, but their connectives are almost twice as long. The former ganglia are smaller, but globular in shape instead of flat, while their commissures are much longer, the anterior being almost as stout as the posterior. The most anterior nerve collar, the cerebro-buccal, is not closely attached to the walls of the œsophagus, but is considerably larger than the latter, being very nearly as large as the cerebro-pedal nerve collar. This latter with the pleuro-pedal are the same as in C. tulipa, with the exception that they both lie more obliquely across the œsophagus. The fourth collar, connecting the pleural and the sub-intestinal ganglia, like the second and third, is much more oblique.

The tentacular and optic nerves are the same, with the exception that the former are not nearly as stout, and have not the kink or elbow bend, the optic nerves issuing from them as already described.

The connective between the right tentacular nerve and the nerve issuing from the right pedal ganglion, and which, in the former species, was so noticeable, is absent in C. textile, there being no connection of any sort between the tentacular nerve and the pedal ganglia.

The left or anterior otocyst is placed closer to the pedal ganglia, while the right one is in about the same position.

The left acoustic nerve issues above the left cerebro-pedal connective instead of below it and follows much the same course, but runs along the floor of the body-cavity under the anterior pedal nerves instead of through them. The right acoustic nerve runs along the dorsal surface of the right cerebro-pedal connective.

There is no difference of note in the proboscidean nerves.

I have already mentioned that the nerve collar round the œsophagus formed by the two cerebral and two buccal ganglia is of much greater diameter. Two nerves (*s.* 3, *s.* 4) issue from the left of these latter ganglia and proceed to the radula-sac in like manner, but are stouter, the fine nerve (*s.* 2) running forward; the buccal-proboscidean nerve is present, but only one nerve from the right ganglion to the radula-sac, and the small nerve (*s.* 1) from the same ganglion to the anterior part of the poison duct is also absent. The main poison gland nerve (*s.* 5) is slightly modified, as shortly after leaving the posterior commissure it is bifurcated, the right branch innervating most of the poison duct. The left branch, after proceeding backwards for some distance, is in turn divided into two, these two innervating the poison gland itself.

Lastly, the fine nerve (*s.* 6) from the main nerve (*s.* 5) to the œsophagus, branches off from the former further back, and on reaching the surface of the œsophagus sends one nerve forward and one back over the surface of the latter. Though somewhat modified, the function of this nerve is the same, and its existence is the chief point in question.

The two columellar nerves having their origin in the left pleural ganglion are of equal size, and slightly stouter, and not so sinuous. Both lie under the œsophagus, and innervate the columellar muscle in much the same way. The four nerves issuing from this ganglion—viz. the main and lesser pleuro-siphonal and the two parietal nerves—differ but little, the anastomosis between the anterior branchial nerve and the main pleuro-siphonal being slightly longer.

I have already mentioned that the posterior portion of the

supra-intestinal ganglion is reflected over to the left. There are only three nerves besides the left loop of the visceral commissure which proceed from this ganglion, namely, the anterior and posterior branchial nerves and one parietal nerve. With the exception that they pass straight across the body-cavity to the left they are of no particular interest. The branch given off from the main or anterior branchial nerve is again present, but much smaller, with the result that the anterior and posterior branchial nerves are closer together, and, therefore, in more normal positions.

The sixth nerve (*c.* 4) in C. tulipa is entirely absent in this species.

The three visceral ganglia and their commissures require no special comment, being much the same in both species, the commissure being slightly shorter.

The difference in shape of the sub-intestinal ganglion has already been noticed. There are only three nerves which issue from the ganglion besides the right loop of the visceral commissure. The nerve (*e.*) performing the functions of a parietal and columellar nerve is absent.

The pedal ganglia are even more closely connected and ensheathed by connective tissue. The nerves leave the right ganglion, with one exception, from its anterior extremity only, while they issue from the left side as well as from the anterior of the left ganglion; thus, more nerves are given off from the left than from the right ganglion—the reverse of what occurs in C. tulipa. In the latter there were 41 nerves altogether from both ganglia; in this species there are 39—21 from the left, 18 from the right ganglia, as compared to 30 and 11. None of these 39 pedal nerves attain so great a size as the chief ones in C. tulipa, and all enter the floor of the body-cavity sooner. The right ganglion supplies the posterior portion of the foot, while the central and anterior parts are innervated from the left ganglion. It will thus be noticed that the functions of the ganglia in the different species have been reversed, since in C. textile it is the left one that is the most important. The ganglia themselves do not lie at so

great a tangent to the longitudinal body-axis, but more at right-angles to it.

There are no points of any great difference, or of special interest, between the nervous systems of both species beyond those already mentioned.

Circulatory System of Conus Tulipa (Pl. 5, fig. 22, and Pl. 6, fig. 25).

As in C. textile, so in this species, I have only studied the artery passing forward through the nerve collars. This artery (*g.*), after leaving the heart, proceeds forward and obliquely to the right till it reaches the left branch of the visceral commissure (*d.*) anterior to the left visceral ganglion. For some considerable distance, both commissure and artery are surrounded by one sheath of muscular and connective tissue, the artery being on the right of the commissure. Owing to the artery and commissure having been cut through, where surrounded by this sheath, while removing the œsophagus from the nerve collars, I at first mistook the artery for a nerve given off from the commissure, and, indeed, had dissected it out as such, being considerably perplexed by the existence of such a nerve, till on having sections cut I realised my mistake. It is owing to this error that I have been enabled to work on the arterial system at all, for being then engaged on the nervous system, had it from the beginning clearly shown itself to be an artery, most probably it would have been removed without much comment, and some interesting facts remained unknown.

Having branched off from the visceral commissure, the artery passes to the right almost at right angles to the longitudinal body axis, and under the œsophagus. A little distance after its separation from the commissure, a branch artery (*j.*) is given off nearly at right angles and passes upwards to form a loop which partly surrounds the œsophagus, while the end of the loop is bifurcated, one branch running up and the other down.

The main artery proceeds through the three nerve collars, pleuro-subintestinal, pleuro-pedal, and cerebro-pedal, till it arrives at the posterior cleft between the two pedal ganglia. Here a stout but very short branch (*op. l.*) opens into the dorsal surface of the left pedal ganglion at its posterior edge. The artery runs down the dorsal constriction between the two ganglia and over the anterior edge. When about half way along the depression between the ganglia, the artery is slightly expanded, and two branches issue, that to the right (*op. r.*) opening into the dorsal surface of the right pedal ganglion, while the left branch (*w.*), which is much longer, is directed upwards and divides into two, each being again bifurcated and spreading over the radula-sac.

The branches opening into each of the ganglia are of the same size and length, but the left one enters the extreme posterior edge of its ganglion, while the right one opens into the centre of the dorsal surface of the right pedal ganglion.

After leaving the anterior edge of the ganglia, the main artery curves to the left, becomes larger, and runs directly forward, two arteries branching off from it on the right side, then one on the left, and still more anterior to this latter, the main artery is bifurcated.

The first branch (*c. ft.*) to be given off to the right, runs backwards and through some of the pedal nerves, and enters the centre of the foot, where it divides into two branches supplying the central portions of the latter.

The second branch to the right (*v. ft.*) proceeds directly downwards into the foot to its ventral surface, where it forms a T, one arm running forward and the other backward. Slightly anterior to this artery, the main artery sends off the only branch to the left (*te.*), which proceeds to the base of the cephalic integuments. The left bifurcation of the main artery (*y.* 1) runs forward through the dorsal portion of the foot, while the right (*y.*), passing downwards into the foot, attains the extreme right anterior basal surface of the latter.

In section, the main and branch arteries are for the most part oval (Pl. 5, fig. 22), and are composed of two distinct

sheaths or layers, of which the inner (*l. c. m.*) consists of circular muscular tissue lined with endothelium (*end.*), while the outer sheath (*l. m. s.*), which is slightly thicker, is built up of areolar and muscular tissue running longitudinally.

Differences between the Artery in Conus Textile and Conus Tulipa.

Although the position and functions of the artery in both species are roughly the same, there are many points of great difference between them.

In the first place, the artery in C. textile has no connection whatsoever with the visceral commissure, and lies entirely under the œsophagus. In C. tulipa, for some distance, the artery and commissure are enclosed in the same sheath, and the artery traverses the nerve collars in a direct line for the pedal ganglia. In C. textile the main artery passes through the nerve collars some distance to the left of these ganglia, and a branch artery crosses the dorsal surface of the pedal ganglia, but has no connection with them. In C. tulipa this branch is absent, but the main artery opens directly into the dorsal surface of each ganglion, while from the same place as the opening into the right ganglion a stout but short branch proceeds to the radula-sac.

The radula-sac of C. textile is supplied from a branch which is given off from the main artery before the latter passes through the pleuro-pedal nerve collar. This branch is bifurcated, the left arm running backwards and through the pleuro-subintestinal collar and supplies the œsophagus, while in C. tulipa the latter has a direct supply from the main artery posterior to the last-named nerve collar. In this latter species the main artery, after passing over the pedal ganglia, becomes considerably larger, runs directly forward and divides up into five branches, which supply the base of the cephalic integuments, the anterior dorsal surface, the anterior right and basal surface, the central ventral, and the central portions of the foot respectively.

In C. textile, anteriorly and to the right of the left pedal ganglion the main artery forms a cross, the left arm running to the base of the siphon, the central to the anterior and basal surface of the foot, while the right arm, which is twice the length of the other two, proceeds directly backwards to the extreme posterior and dorsal surface of the foot. Lastly, in section, the artery is of a different construction in each species. In C. tulipa it is composed of two layers of tissue, of which the outer, or tunica adventitia, which is slightly thicker than the inner, is built up of areolar and longitudinal muscular tissue. The inner layer, or tunica media, is composed of muscular tissue running circularly round the arterial canal, and having a smooth inner surface lined with endothelium, or pavement epithelium. The reverse in every point, except the endothelial layer, is the case in C. textile. The outer layer, which is half the thickness of the inner, is built up of areolar and circular muscular tissue; the inner layer is a confused mass of circular and longitudinal tissue of the same sort; while the internal surface, which is lined with endothelium, is deeply corrugated, and a section looks more like a vein than an artery. The total thickness of the arterial wall in this species is twice that in C. tulipa.

Though superficially resembling one another, from the foregoing comparison the many and great differences between the arteries in the two species will be observed.

Poli (21), pl. xlv, fig. 13, and p. xxxix has illustrated and described in Conus rusticus Linn. an artery which he calls "l'aorte abdominale," which is similar to that in C. textile in some respects. According to Poli's figure, the artery runs forward from the ventricle of the heart beside the left loop of the visceral commissure, across the latter, and forward through the nerve collars, where it is anteriorly split up into several small branches.

In concluding this paper, it is hoped that the contents on the anatomy of two species of the genus Conus may be of use to workers on this group. Since I commenced my work on this genus I have received from various sources a number

of different species, and I hope shortly to be able to start work on them with a view to further determining the anatomical variations between different species.

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EXPLANATION OF PLATES 1–6,

Illustrating Mr. H. O. N. Shaw's paper "On the Anatomy of Conus tulipa, Linn., and Conus textile, Linn."

LETTERING IN ALL THE FIGURES EXCEPT NUMBERS IN FIG. 20.

a. Anastomosis between pleuro-siphonal and anterior branchial nerves. *ac. l.* Left acoustic nerve. *ac. r.* Right acoustic nerve. *ats.* Tooth attachments to sac wall. *B.* Buccal ganglia. *b.* Anterior branchial nerve. *b.* 1. Branch off anterior branchial nerve. *b.* 2. Posterior branchial nerve. *b. a.* Basal attachment of radulæ. *b. c.* Body-cavity. *br. c.* Branchial cavity. *bs.* Barbs of teeth. *C.* cerebral ganglia. *c.*, *c.* 1, *c.* 2, *c.* 3. Parietal nerves to left of body. *c.* 4. Main and posterior parietal nerve. *ca.* Canal. *c. b.* Cerebro-buccal connectives. *ce. pl.* Cerebro-pedal connectives. *c. ft.* Artery to centre of foot. *c. m. s.* Circular muscular sheath. *co. i.* Inner corneal layer. *co. o.* Outer corneal layer. *ct.* Ctenidium. *d.* Visceral commissure. *d.'* Pleuro-sub-intestinal connective. *dt. op.* Duct opening. *dts.* Ducts from unicellular glands. *e.*, *e.* 1. Parietal nerves to right of body. *e.* 2. Columellar nerve. *e.* 3. Right pleural nerve. *end.* Endothelium. *ep.*